ISLAMIC LAW FOR WATER AND LAND MANAGEMENT AND ITS IMPACT ON URBAN MORPHOLOGY

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ABSTRACT Urban morphology and territorial landscape of Islamic cities were deeply affected by the Islamic law that regulated the ownership, distribution and use of water and land. Due to the climatic exigencies and the economy of subsistence that was mostly based on agriculture, water was a precious liquid that was treated with special care. A sophisticated system of subdivision of shares was developed by jurists from the succession law and right of ownership over a long history of daily practices and cumulated body of legal opinions.
Consequently, the analysis of urban forms in Muslim cities cannot bypass the study of these mechanisms that are found in books of jurisprudence, archives and courts records and the people's practices that are rooted in the local traditions and that are still standing in some parts of the Muslim world.
The present study aims at presenting these mechanisms and shade light on their physical impact in the Muslim cities. The complex geometry of land subdivision in both urban and rural areas, and water irrigation system are analyzed through the available maps and aerial views. Cities such as Blida, Kolea and Tamentit, Algeria, provide sufficient documents for the study of this relationships between the Islamic law and the urban form and thus, serve as case studies. The study aims at presenting a good example of the interaction between human needs, faith and spirituality, and laws of nature, and thus add a new dimension to the concept of sustainability.

Key Words: Islamic law, Land, Water, Rights, Urban Morphology, Muslim Cities.

1. INTRODUCTION

Muslim cities were often dictated by the hot climate and sun, and thus were characterized by their "solar architecture". However, it is often ignored that the same cities have also developed a sophisticated "water architecture" that stemmed from the scarcity of this element and the special care drawn to it. It has been a major factor that shaped and sometimes dictated the morphology of some traditional Muslim cities.
Landscape of the territory of cities was for instance marked by major elements that brought water from remote sources. Aqueducts as suspended canals crossing mountains and dunes created a territorial architecture that marked the physical environment of Cordoba[1], Algiers and many other cities).
In desert cities this same element was inverted. Water was drained in an underground gallery in order to protect water from sand storms and evaporation. Desert cities in Iran, Afghanistan and North Africa present a characterized territorial image of successive wells, often covered with domes that penetrate the city urban fabric. So, looking from the air, sets of wells look like a line of small craters (Figure 1). Some of these wells are consequently covered with parapet walls giving them

[1] Benhamada S. Al-maa'wa al-insan fi al andalus Dar al-Taleea, Beirut 2007. p 115. Cordoba used to have an aqueduct that has a unique bridge that had 19 arches, each measuring around 50 palms.

cylindrical shapes, and others have domes creating a very characterizing urban furniture.
Water brought from many canals is gathered in common pool that have very characterized architecture that is shaped by water movement and topography. Pools and collectors have different forms and sizes from which diverge many smaller channels.
Land was subdivided into parcels in a linear form that goes in parallel to the canals. Parcels had a modular pattern that defined the territorial landscape, defined by the system of cultivation, the trees sizes such as palm trees, and oranges. Rights for irrigation however the locations and forms of these plots were, stressed this modulation.
At the urban level, the city was also shaped by water. The urban space was framed with a grid of fountains, *sabeel* , that provided water to passersby[2] as well as residents. Rain water was stored in wells and pools, and drained to streets through extended elements from the roofs called *Meezab*.
Drainage of rain water were also present in this natural design process. The urban pattern of Algiers old city, was developed on the versant of a dune facing the sea that helped discharging used water efficiently.
In desert, the underground irrigation system was combined with wind-catcher techniques to provide freshness. Where water tunnels run beneath houses, special rooms were constructed beside the underground stream with tall shafts reaching upward to wind-towers above roof level. Air caught by the wind-towers, was forced down the shaft, circulates at water level, and provides a cool refuge from the afternoon heat of summer[3].
The following sections will highlight the tripartite relationships between the urban morphology, human needs for water (and land), and the Islamic law. At a higher level, it gives a new sense to the concept of sustainability that relates urban development to the laws of nature on one side, and the metaphysical mind that constitutes the way the Muslim mind perceives the environment.

2. THE MORPHOGENESIS OF CITIES

Opposite to the well known model of Muslim cities that are mostly irregular and organic, the present work presents cases of cities that have a relatively orthogonal network that has been dictated by the by the water channels and irrigation system. A similar study was made by Bonine M. (1979) on the Iranian cities that have the same irrigation system[4].
It is not the intent of the author to establish an exhaustive list of these cities but rather to present some examples and highlight the relationships between the urban morphology and water[5].

2.1. Blida And Kolea

The urban structure of the city of Blida was highly shaped by the irrigation system. Its location was first determined by the availability of water and the fertile land that characterizes the Mitidja plain[6]. Its road pattern was marked by the canals of water that infiltrated the city towards the agricultural land (Figure2). The river called sidi

[2] In Algiers there were around 100 fountains forming the water grid of the city and insuring the provision of water to all the residential quarters.
[3] Qanats p5 available online www.waterhisotry.org
[4] Bonine, M. E., (1979). The Morphogenesis of Iranian Cities. Annals of the Association of American Geographers. **69** (2), 208-224.
[5] Cities presented here are selected on the basis of a personal interest and field studies that made documentation and urban history available.
[6] It occupies the coastal central part of North Algeria.

Ahmed Al-Kebir was first diverted from its initial path, initially directing from north to south, in order to protect the agricultural space from floods and permit control of the descending water (Saidi 2002: 389). The diverting point served thus as a delta from which many canals departed in the form of an open hand with 8 fingers towards north and thus replacing the large river flow. Agricultural plots developed accordingly in a linear form parallel to the waterways. Channels and small dams were built with clay and stones conducted water to all parts of the city in response to the local population needs for irrigation and potable water. Many fountains were also built near the main gates of the old city (Saidi M. 2002).

Channels were further subdivided into smaller streamlines to reach the smaller plots that resulted from the subdivision of land according to the succession law. In fact the continuous subdivision of land entailed the redefinition of the irrigation system in order to insure the share of water for each new parcel.

The initial irrigation system helped Saidi M. (2000) to redraw the morphology of the city through the reconstruction of both the agricultural parcels and the building parcels. Due to the periodic maintenance and the right of passage known in the Islamic law that gives access to the channel, paths seems to have developed along these channels and turned into streets and roads. The hierarchy of the irrigation system thus should have shaped the present roads network and circulation system. In the absence of major topographic constraints and a homogenous slope directing north-south the channels and consequently the roads were straight and diverged from the old city core to its periphery.

This could be also said about the city of kolea that was also founded in response the same Andalusian population as in Blida, that fled Muslim Spain to North Africa (Saidi M. and Librato P. 2004)[7]. Being on the slope, roads were parallel to each other and would have been running along the channels that were traced by the water of springs that originated from the summit of the city, among which Ain Hlalef, Ain Lalla Ruba and Ain Sidi Ali[8]. As an agricultural settlement, the urban fabric of the city would have developed from the agricultural parcels into a row of back-to-back houses[9].

Figure 1: Foggara wells along streets in Adrar (Algeria)

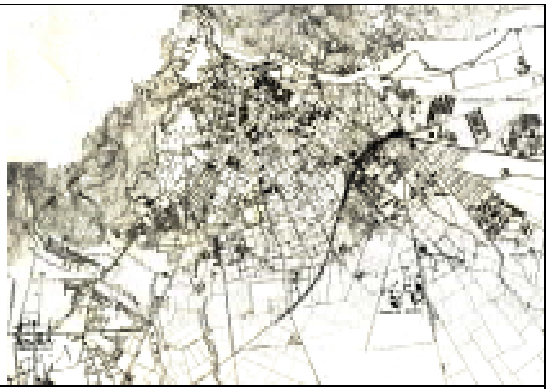

Figure2: Blida and its periphery showing the traces of water canals

[7] Saidi M. and Librato P. (2004) From the grid to the labyrinth. The Medina with a Roman Substratum in the cases of Miliana and Koléa, Algeria. International Seminar "The Mediterranean Medina" June 17-19, 2004 Pescara, Facoltà di Architettura Francavilla a Mare, Museo Michetti.

[8] The information was provided by an old lady (around 70 years old) who lives since here childhood in this city.

[9] This deduction is in contrast with that of Saidi M. and Librato P. (2004) who consider that the morphology of the city was shaped by the Roman grid. In fact their article provide no evidence of such an influence. It seems thus to be a mere glorification of the Roman model and belittling of local know-how that is reflected in the title of the article.

2.2. Tamentit

The city is located in the region of Touat that is in the heart of the Algerian south-west part of the Sahara.. The city that goes back to 570 AD, was the crossroad of many desert and commercial roads among which the Sudan road that relates north Africa with Black Africa. It was thus an important pole of cultural and commercial exchange (Martin M.G. 1906)(De Colomb L.1860).
The city is formed of many compounds that represents autonomous neighborhoods known as ksour, and that are separated by streets (Suter K 1952). Each ksar is squarish in form and is enclosed within a surrounding wall that comprises watching towers and a unique gate. Echallier (1972:51-60) described the chronology of their development in detail despite the scarcity of information.
The geologic structure of Touat seems to have dictated the orientation of the settlement. Foggara, that are the underground canals providing the settlement and the oasis with water, are directed East-West in consequence to the presence of Tademait plateau. Three of these Foggara, after reaching the palm-tree gardens, pass through the ksar and irrigate the oasis of the other side. The city is thus surrounded by oases that form a microclimate within the town[10].
In the absence of a major topographic constraint and the presence of a small slope, the city shows an orthogonal pattern that corresponds to the development of streets in parallel to the water channels (Figure 3). It oasis is also ordered according to these channels and are structured in accordance with the palm tree that became the territorial module. A better understanding of this morphology requests an insight in the hydraulic system that is known as *Foggara* .

Figure 3: Tamentit; an aerial view showing the oasis, the city and the canals

2.2.1. The system of Foggara

The system of Foggara consists of conducting water through an underground gallery from a remote location to a human settlement and an oasis. Its utility is to

[10] One of these fouggara known as Hennou is the oldest one and pass under ground of the settlements and thus seems to be older that the settlement that was founded around 517 AD.

minimize the community's efforts and time of the daily search for water, to prevent evaporation and dust due to the harsh climate, and to keep water fresh and cool. Initially, the wells are established to provide air and light, and enable the workers to dig horizontally and create the gallery (Figure 4). But they are also maintained in order to enable the community to carry out the annual maintenance and repair the gallery in case of obstructions that are caused by the sand storms.

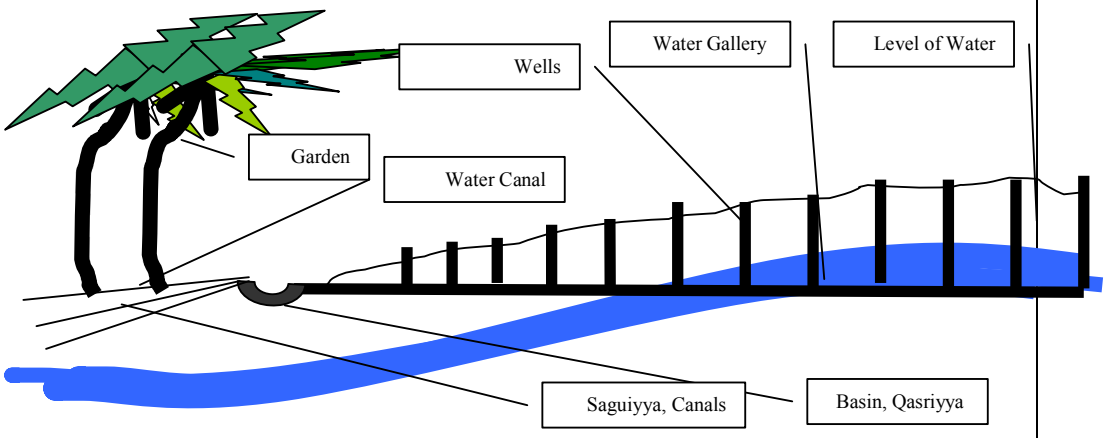

Figure 4: The system of Foggara and its components

The system, is also known in other Muslim countries such as Iran[11], Oman, Emirates, Yemen and Morocco. It is believed to have been developed along time ago in the Middle-East pre-Islamic period[12].

In Algeria, the region of Touat within which Tamentit is located has a network of underground canals that has in total around 2000 km in length[13]. The system although defeated by the modern system is still in use in most of the old settlements[14].

Regarding the process of construction, once the location of the first well is defined that is always in the highest altitude, a series of other wells that will have lesser depth, distant 5 to 10 m from each other, are established. The total length of a foggara might reach 8 km, 10 and even 15 km. An old foggara is an outcome of an incremental work of generations that is undertaken in consequence to the decrease of water level or a communal project of improvement. A horizontal gallery that is located in 10m to 12 m depth in the ground links between these wells. Water drainage is insured through a light slope that is in the range of some millimeters per meter. Its width has a diameter of 1 to 1.20 m that is sufficient for a person to pass through for repair and further digging. Once this gallery reaches the oasis and/or the settlements it appears on the ground surface as a canal and flows towards a large basin, called Kasriya, from which water is distributed to farms and gardens. Water doesn't come only from the first well but also from the walls of the other secondary wells through infiltration (figure 5).

The subdivision of water is done by a public agent known as Kiyyal al-Maa (measurer of water)[15]. A special technique that relies on mathematics and geometry of circles was developed to measure shares and distribute water. A table, made of

[11] Among Iranian cities that rely on this system we can state: Hamedan, Qazvin, Neyshabur, Kerman and Yazd. See http://www.destinationiran.com/Kariz_(Qanat).htm accessed on July 15, 2008.
[12] The system is was known under different names such as Qanat(s) and Kariz in Iran, and Aflaj (pl. of falaj) in Oman and Emirates, and khittara in Morocco. See Qanats available online www.waterhisoty.org
[13] *zoumine.free.fr/tt/sahara/donnees_geo_clim_bota/foggaras.htm*
[14] The last fouggara seems to have been dug in 1984.
[15] De Colomb Les Oasis du Sahara p 35

copper, that has many holes of different sizes, reflecting the fractions of Islamic law of heritage, is used to create orifices within the outer wall of the main basin in the direction of the gardens. A comb-like form called shebka (network) through which water is chanelled into smaller canals and streamlines called seguiyya, is then formed (De Champeaux G. p22-24)(Figures 6 &7).
At present, many of these Foggara have lost their water due to the continuous hydraulic and drilling works in the 1970's and 1980's that extracted large quantity of water. Urban sprawl also covered areas through which Foggara passed and thus led to their destruction and pollution with sewage and other used water[16].

3. ELEMENTS OF THE ISLAMIC LAW FOR WATER AND LAND

Islamic law should be first placed within the metaphysical framework that governs the Muslim mind and vision to the cosmos and that constitutes the general beliefs. Within this universal order, the human is believed to fulfill a mission on Earth that is known as *khilafa* and/or *istikhlaf.* Land and water are thus perceived as parts of this general ecosystem.
On the other hand, Islamic law also relies on endogenous norms that govern the ideas and actions of the Muslim individual. Legal rules and moral reasoning are thus interwoven and dictate human actions regardless of external authorities. These latter intervene only in case of deviations in order to correct misconducts, misuse and abuse of rights.

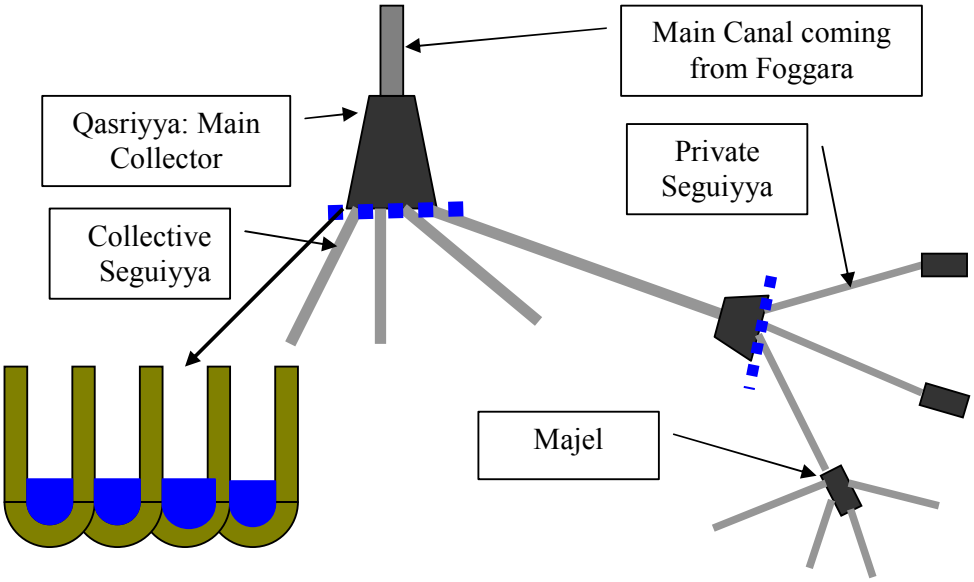

Figure 5: The principle of Fuggara system of irrigiation

These two features give a special meaning to the concept of sustainability that render it an integral part of Muslim environmental culture. It is within this framework that Islam urges humans to rationalize utilisation of natural resources and fight any spoiling, harmful and destructive actions as it considers that in contradiction with the supreme mission. It considers basic human needs as vital and recommends

[16] A regulation was established in 1996 in the wilaya of Adrar to protect the Foggara system (Wilaya Decret no 426, dated 23 june 1996). until recently, qanats still supplied 75 percent of the water used in Iran, for both irrigation and household purposes.

equitable use of these resources. Protecting the public realm and establishing the general legal framework is thus coupled with the insurance and promotion of individuals rights.

In legal terms, there is no fragmental field of 'Islamic water and land law' but rather a set of overlapping themes or domains of *fiqh* that deal with these two issues. Water and Land rights in Islam do not exist in isolation from other parts of Islamic law (UN-HABITAT 2005).

Water and land were specifically mentioned in many occasions in the Quran for they paramount importance[17]. In reference books of legislation they are sometimes classified in special rubrics, and in others are treated jointly. Among the major rubrics of *fiqh* in which water and land issues could be found we can state; public interest, right of ownership, succession law, easement law, right of passage, right of preemption, right of precedence, customs law and servitude zone "hareem" of trees, wells and rivers (Garbrecht G. 1983).

3.1. Ownership and Possession [18]

According the Muslim jurists, water legally ranges between two statuses with regards its origins and the degree of human needs. It is either public or private. Large rivers and lacks, rain water and springs with abundant water are considered of the first category, and are thus shared equally[19]. Sources that emerge in private properties, and wells and canals built by individuals is of the second one. As a private property, it could be subjected to regular forms of usufruct and transactions such as selling, endowing, donating etc (Benhamada S. 2007b).

A foggara for instance might be private or collective depending on the way it was constructed, by an individual, or by a social group. However it is in practice constructed and maintained by the whole society. In some cases a wealthy person could create a Foggara and join it to the common one adding its water to the general flow. Its outcome water is then added to the whole. However he gets half of the added quantity from the out-coming debit, in counter part of benefiting from the main gallery.

Ownership is sometimes conditioned by public interests. In case of scarcity and extreme need, and/or excess of water beyond the individuals needs, public authorities are called for intervention. Possession of flowing water from a spring in one's property or a river passing through that property does not give the right of preventing the others from benefiting or using it improperly. It is thus an imperfect property, or a form of possession, called in legal terms *Hiyaza*, that gives the right of use only. This form has an implication in case of scarcity of water where water rights are allocated according to priorities (the closer to the spring), merit (efforts made to bring water), and degree of need (thirst, basic needs).

3.2. Revivification of Dead Land

This mechanism is based on the principle of the freedom of action that is granted by the Islamic law to individuals within the general concept of vicegerancy, *khilafa*. A dead land *mawat* is by definition any piece of land that is not used, not owned and that shows no sign of prior appropriation. The act of reviving consists of bringing water to a dry land or drying a swampy area so that it suits agriculture and other aspects of development. Jurists agree that revivification is the first step of appropriation *Hiyaza*, by which land could be owned (Kami E. died in 1723, 2000: 426-438). However, they disagree regarding the permission of the ruler.

[17] Surat "Tell them that water is shared among them, and each one should have his own share", Quran 54:28. In the Sunna for instance "People share three things: water, grass and fire" Kami E. died in 1723 (2000): 478.

[18] The present section is limited to water. Land has been treated in many other studies.

[19] The first category is supported by the sayings of the prophet stating that "People share three elements: water, fire and grass" and that "extra water should not be prevented" Al-Bukhari vol 3-p200, Muslim vol5, p34-35.

There is a symbiosis between water and land. Revivification is often made by the establishment of an irrigation system such as digging springs and wells, and laying canals from existing sources of water.
In the case of Tamentit for instance, the area of revivified land depended on the quantity of water. The decrease of level of water also led to the gradual shift of green land. Parcels located in higher level were abandoned while new land which water reaches was revivified. The city thus witnessed a successive shift of its oasis to lower level. In extreme cases settlements were abandoned when water ground vanished, while new ones were born when a new source of water was discovered.
On comparing foggaras in two different dates, 1670 and 1906, Martin AG (1906, p254-255) found that in 1670 there were 36 fouggaras in Tamentit having a total debit of around 70 habbas (210 liters per minute). In 1906 it has increased to 2083 habbas and thus led to the extension of the farming area and the population growth. Revivification process depended on the availability of water, its ground level and location of new sources [20].

3.3. Servitudes Zone Hareem

Opposite to the previous principle, the Hareem concept consists of defining a buffer space around trees, wells and springs or along rivers and canals that preserve their use and prevent any other activity. A well for instance should have a servitude zone around it between that has a radius between 40 and 60 cubits as it is used sometimes for animals, while a spring might have a servitude zone of 500 cubits (Kami E. died in 1723, 2000: 442). Any other well or septic fossils as well as a building should therefore not be permitted to be built within this zone.
Also a tree has a servitude zone that insures its roots to develop and its leaves and branches to extend. It is estimated to be 5 cubits. A similar unit of space was developed in Bahrain to measure land though the number of palm tress that is known as *Maghras*. A garden could thus be measured through the number of trees that have each this module of land. This module also served jurists to investigate in case of conflict between contiguous properties regarding boundaries and harvesting.
Land in the vicinity of cities and villages is regarded as buffer zones, *hima*, that serves residents for wooding and grassing and thus is excluded from revivification. However, other jurists consider that unused land within the city is a residual space left behind the act of revivification (Al-Qarafi S. E. (lived between 626A.H. and 684A.H.). It could thus be developed in continuity to the early action. This in fact what happens in the Muslim cities where a continuous appropriation of unused spaces takes place over centuries and leads to a complex geometry of cumulated solutions.
Within the urban space, adjacent outdoor spaces along houses walls were considered as a servitude zone for houses that are called *fina*. Umar Ibnul-khattab, the third caliph, judged that fina(s) belong to the owners of houses for their utility. However, they were not allowed to build it.
Canals had also a linear *hareem* zone that permitted repair and periodical cleaning. Rivers have also their own linear zone that prevent people from building along it. In most of cases, this zone turned into a path along the canals.

3.4. Subdivision of Succession law

Islamic law of succession is one of the areas of jurisdiction that had the most impact on physical environment and urban geometry of cities. It departs from the principle of distribution of wealth and resources among individuals for social justice. It thus

[20] Echallier J. C. Village desertes et structures agraires anciennes du Touat-Gourara Arts et Metiers Graphiques, Paris 1972.

combats monopole and class segregation. However, it leads sometimes to thee fragmentation of the properties that sometimes hinder their use and usufruct.
Jurists developed tools and techniques for the subdivision of wealth such as land and water. Books of jurisprudence abound with examples and real cases of subdivision (Al-Rami XV Century, Al-Wansharissi died in 914 AH, Kami died in 1723). Water was considered as part of things that could be owned, inherited and thus subdivided. Qanat and fouggara system gives a sophisticated system of subdivision and fractioning[21]. A table of copper that reflected the shares according to Islamic law was manufactured[22].This fractioning is reflected in the shape and size of the canals and streamlines that are built hand-free using clay as a material (Martin A.G.P. 1908) (Figure 6).
An example of a fuqqara subdivision of water would be for instance among 36 people that built it. If the resulting water is for instance 86 habbas the quantity of water will be subdivided on 36. that will give 86/36= 2habbas and 14/36 for each. The denominator of the latter fraction need to be changed from habba to qirat in order to be subdivided and thus is multiplied by 24. So 14/36 habba x24= 336/36 that is 28/3. Each member will thus have in addition to the previous 2 habbas, 9 qirat, and 1/3 qirat will remain. The latter will further be subdivided into fils and will be multiplied by 24. The final result will thus be that each members will have 2habbas, 9 qirat and 8 fils.
Besides the subdivision of the debit into fractions, water was also subdivide according to a time schedule that is based on the moon and stars positions. Once the water is collected in the general collector, called *Majjel*, Qasriyya and *sahreej*, a continuous opening and closing actions of water channels took place within the oasis.

3.5. The Customs Law Urf Role of Custom and Istis-hab (urf)

Islamic law gave importance to local traditions and customs of each region and considered it as a source of legislation as far as they don't clash with the principles and ethics of Islam. Local and pre-Islamic practices have therefore persisted in the Muslim world and gave variety within the general framework of Islam (Hakim)[23]. Measurement techniques, tools and instruments, and management systems of water and land were therefore preserved in each region. On the other hand, the open borders within the large territory of Islam permitted the exchange of practices through the migration and travels of Muslim individuals and social groups.
For instance, Andalusian community that fled to North Africa in 1535, brought new ways of irrigation and farming that shaped the new cities such as Kolea, Blida, Algiers and Cherchell (Saidi M. 2003). It is most probable also that other migrations took place from Oman, Persia and Yemen to the Maghreb and introduced the system of Foggara that is strikingly similar to Aflaj of Oman and Emirates, and Qanat of Iran.
Public agent known as Kiyyal al-maa and the technique used to measure the debit and subdivide water according to inheritors share would also be part of the customs.

[21] The measurement is based on a unit this equivalent to t he width of a finger, that It is approximately 9mm in some areas and 27mm in others. The unit of measure called the habba or sebaa' أصبع, is the quantity of water passing in a night and day in a hole that has a width of a small finger pierced in a table of copper. It is equivalent to 3.50 litres per minute. This unit is further subdivided into other units. It is equivalent to 24 kirats or 96 dirhem (4 per kirat) or 144 kharrouba (6 per kirat) or 576 mouzouna (6 au dirhem or 4 a la kharouba, or 2304 farfouria (4 per mouzounia)
[22] The table is designed to give the fractions that are known in Islamic law of succession. The first raw at the bottom there is a series of equal holes that have the size of a small finger called habba. In the second row the holes are larger but of equal sizes that is 7 habbas. In the last upper row the holes are of different sizes and reflect the fractions 2/3, ½, 1/3, 1/4., 1/6, 1/8, 1/12, 1/24. this latter is called the fils or qirat. The qirat is itself subdivided into other fractions that goes in smallness to the needle of the palm tree.
[23] Hakim, B S (1994) The "Urf" and its role in diversifying the architecture of traditional Islamic cities. *Journal of Architectural and Planning Research* **11**(2), 108–127.

Both time-based and debit-based categories of Foggaras were thus either imported or adopted from the other communities within the legal framework of Urf.

3.6. Easement and elimination of Harm

On granting the right of property and freedom of usufruct, the Islamic law permitted also the transaction and exchanges of services and benefits among neighbours and partners. It however set rules that prevent damage and protect neighours and public. Intervention of public authorities was mostly limited to the authentication of agreements and accords, solving conflicts that brought to courts, and defending public realm from private violations.

Passing through another's property or draining water through neighbours assets was a common practice that is known in the rural as well as urban areas due to the continuous subdivision of properties and transactions. The passage of water and person on others property was done either on the basis of the ownership; a footpath or canal a being owned or bought, or through the acquisition of the right of passage *Haq al murur*, and the right of drainage *haq al masseel* that is granted due to a previous subdivision or a precedence, or though charitable donation.

According to Ibnu al-Rami (XV century, 1995:587), a person might own a palm tree within another's property. The land owner has thus no right to prevent the owner of the tree to reach it, maintain it and harvest it. However, if the land is planted the owner of the tree should find the optimum path that doesn't cause any damage to the plantations. A similar legal opinion was stated in the case of a person who owns a piece of land within many other properties whose owners want to prevent him from passing through. Ibnu al-Rami (1995: 594) states that they should reach an agreement among themselves to provide access to him and could not prevent him. This also applies in case he wants to develop his property into a house or any other building. Similarly, if they decide to develop their properties into constructions they should decide about the location of the path that lead to the central property.

In most of the cases agreements are reached among neighbours and partners after long discussions and in the presence of other members of the community as witnesses and mediators. Most often the concerned parties are motivated by their religious convictions and moral values that urge for good deeds. A right of passage and/or drainage on another's property could also be shifted from a location to another as far as the owners of the concerned land agrees.

Such a flexibility permitted a dynamic birth and extinction of rights and servitudes that was reflected in the geometry of plots and engineering solutions away from the direct intervention of the authorities. Figure 6 Shows for instance how two crossing were designed in the form of two flyovers.

Figure 6: a small water distributor

Figure 7: a fly-over channel

4. Conclusion

The urban morphology of the old Muslim cities that are located in desert has been highly shaped by the movement of water and the early form of land parcels that were initially set for agricultural purposes.

One of the most important lessons of these case studies is the new dimensions added to sustainability concept in accordance with the Muslim mind and the long practice acquired through city making experience. Endogenous norms that stemmed from the Islamic metaphysics turned into an Islamic legal framework that highly shaped the actions of people on the built environment. The example of the Foggara system shows how these actions go in line with the laws of Nature that kept balance between natural resources and human needs, and reflected the Islamic beliefs and rules of conduct.

Such a symbiosis between the environment, the human needs and religion gives an image of a sustainable development that used to govern our human settlements before the advent of industry and powerful technology[24].

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[24] Some private Foggara become a favorable site for fish breeding and provide a large quantity of fish.